MILITARY OPERATIONS RESEARCH SOCIETY

Mini-Symposium Report

Complexity in Modeling and Simulation - Linkage

James J. Sikora, FS and Dr Marion L. Williams, FS, Co-Chairs

24 - 27 February 1997
Albuquerque, New Mexico

Co-hosted by:
Air Force Operational Test and Evaluation Center
BDM International, Inc.
Sandia National Laboratory

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OVERVIEW OF MINI-SYMPOSIUM

Background

The use of Modeling and Simulation (M&S) of military systems has dramatically increased because of decreasing DoD budgets and rapidly advancing computer and software technology. There has been an explosion of new M&S projects to take advantage of this new, more efficient technology and to create cheaper to use, more capable tools for military applications. The advancing M&S technology areas include methodologies and techniques for linking different M&S together as well as for use in conjunction with other warfare analysis tools. The ability to technically link various models has increased significantly, but now we must also determine how to 'logically' link to achieve analytically sound results. There are issues concerning the ability to link or integrate the M&S for any particular application. These issues involve the linking of models of different levels and types. As an example of a different type of linkage, the linkage of a cost model and a performance model has been accomplished by analytically combining each models results. Are there more effective and faster means of accomplishing this linkage? An equally complex set of issues exists for linking the executions of a different level of models, for example, a theater level model and a mission level model.

Another area which will affect the linkage and integration of M&S is the use of common M&S elements and standards. This commonality is particularly important because of increasing M&S requirements and decreasing budgets for satisfying those requirements.

Objectives

The objectives of the proposed Mini-Symposium were to:

(1) Identify and discuss issues, concerns, and problems (with any identifiable solutions) associated with M&S linkage.

(2) Review selected current and future M&S linkage activities and projects with a focus on the impact on analysis applications and analysis capabilities. The focus also included the activity/project objectives/requirements as well as any linkage lessons learned.

(3) Increase the military application community's understanding of M&S linkage issues, problems and potential solutions.

(4) Provide interface/interactions among the members of the military applications community in the area of M&S linkage.

Agenda

The agenda for the four-day unclassified Mini-Symposium contained the following two major segments:

Segment A. Analytic M&S Linkages

Session 1 - Linkage of Different Levels M&S

Session 2 - Linkage of Cross-function M&S

Session 3 - Linkage of Cross-community M&S

Segment B. New Technologies Supporting Linkage

Session 1 - Linking Through A Common Understanding of the Battlespace

Session 2 - Linking Statically Through Data Sharing

Session 3 - Linking Dynamically at Runtime

The Mini-Symposium began with a short introduction and an overview of the M&S linkage area, the Mini-Symposium objectives and an overview of the Mini-Symposium

agenda. The remainder of the first day was taken up with Segment A - *Analytic Linkage*. The second day contained Segment B - *New Technologies Supporting Linkage*. The Mini-Symposium closed with a panel discussion by the segment Co-chairs and MORS Sponsors' Representatives who consolidated the issues and concerns identified during the meeting.

The formal program was preceded by a tutorial on the Common Technical Framework (CTF)/High Level Architecture (HLA). The formal program was followed by a half-day working session to collate, integrate and summarize the issues and concerns identified during the Mini-Symposium. The session attendees were the Mini-Symposium Co-chairs and other interested attendees. The effort of this session is presented in the ISSUES AND CONCERNS section of this report.

[Reviewer Comment: In the course of this special meeting many suggestions were made for MORS to hold more meetings on this subject. Due to resource constraints some of these requests may need to be met through other forums.]

ISSUES AND CONCERNS

Issue 1: *How do we do Verification, Validation, and Accreditation (VV&A) of linked models? How much is enough?*

Description: VV&A is a significant issue in DoD modeling and simulation, particularly where federations of models and simulations are linked together. In such cases, both the individual simulations (or federates) must be V&VA'ed and the federation as a whole must be VV&A'ed. VV&A requires documentation of the credibility assessment performed on a given model, simulation or federation, to ensure complete understanding and insight into the model, simulation or federation by all players in the VV&A process.

This requirement also facilitates reuse of the model, simulation, or federation in that the results of previous VV&A efforts are available to future users who may leverage those earlier efforts where the VV&A required for the new use is sufficiently similar to previous uses. Discussion of VV&A during the Mini-Symposium revealed three primary areas of concern or need within the analytic community: the cost of doing VV&A, the lack of adequate education and the need for VV&A support tools.

Possible Approaches:

a. MORS has already provided DoD with a sound foundation for verification, validation and accreditation through its Simulation Validation (SIMVAL) Workshop series. It is recommended that a follow-on SIMVAL Workshop be held to address the concern of the cost of doing VV&A to further provide DoD with insight into this key issue.

b. MORS can also provide some leadership in the area of VV&A education; however, it is recommended that the Defense Modeling and Simulation Office (DMSO) continue to pursue this area, as well as the development of VV&A support tools.

Issue 2: *How do you get logical consistency in linked simulations? How do you know when you have it?*

Description: Technology (the High Level Architecture (HLA) and supporting tools) now offers the analyst the option for linking simulations to support analytic applications. This technology provides standard mechanisms for exchanging data among linked simulations (HLA runtime interface and runtime infrastructure) and for specifying information exchanges among linked simulations (HLA Object Model Template and Object Model Development Tools). To usefully link simulations for analysis, it is important that the internal representations in the linked simulations are appropriate to the problem being addressed and consistent across the federation of simulations to the degree required by the analysis problem. For any linked federation of simulations, the analyst must ascertain which simulation characteristics are relevant to the analysis at hand, to identify simulations which match these characteristics and to verify that these are represented across the federation in a way which together support the requirements of the application.

Possible Approaches: A potential approach for addressing this issue is a series of MORS Workshops to bring analysts together to accomplish the following:

a. Develop a common understanding of those aspects of internal simulation representation commonly of relevance in assessing their appropriateness for a linked application (e.g., approach to management of time and space, model assumptions and algorithms and level of resolution and detail).

b. Characterize these aspects so that simulations can be reliably described in terms which will aid analysts in assessing their appropriateness for inclusion in a linked analysis application.

c. Document simulations in these terms and make such information readily available to potential simulation users.

d. Develop automated methods for assessing consistency of internal representations across federations of simulations.

Issue 3: *How do we identify appropriate uses of linked models and simulations for analysis?*

Description: Recognizing that modeling and simulation is just a tool for the analyst, this issue should be addressed in the broad context of four areas. These are:

- The range of the types of analyses performed in support of the military;
- The types of linked models and simulations that are possible;
- The availability of relevant data for the problem at hand; and,
- The degree of confidence desired for the findings of the analysis.

In addressing this issue, two preliminary tasks are appropriate. The first is to identify the classes or types of analyses conducted in support of national defense. The second preliminary task is to identify classes or types of federations of models and simulations which are likely to have potential for supporting military analyses. Given that two such lists were produced, it would be useful to develop guidelines for analysts to determine, in general terms, which types of models and simulations would be appropriate for various types of analyses. These guidelines could be implemented in the form of a list of questions or considerations on topics in the areas of:

1) The conditions for the analysis.

2) The characteristics of the modeling and simulation being considered.

Examples of considerations relevant to the analysis are:

- The cost ceiling for the analysis;
- The time to complete the analysis;
- The number and type of iterations required; and,
- The fidelity of things and interactions being represented in models and simulations required for the key analysis measures.

Factors relevant to the characteristics of the modeling and simulation include:

- The repeatability of model and simulation runs;
- Ability to accredit the federations of models and simulations;
- The types of representations (e.g., physical, phenomenological, behavioral);
- The degree of disparity among the linked models and simulations in terms of resolution, aggregation or fidelity; and,
- The cost of generating and running the linked models and simulations.

Also important in deciding whether or not any modeling or simulation is appropriate for an analysis is the consideration of other methods that are simpler.

Possible Approach: The recommended approach for addressing this issue is a MORS Workshop. It is envisioned that the participants would be a mix of defense analysts, practitioners in linked models and simulations and users of analysis products. In addition to producing guidelines for appropriate uses of linked models and simulations, an important benefit of the workshop would be to establish a better mutual understanding of this issue among the professional communities involved. Principally this understanding focuses on the capabilities of

linked models and simulations, the needs of the analysts and the ways decision makers use the results of analyses. The scope of the workshop would be limited to developing general guidelines for selecting potential linked models and simulations for various types of analyses. Although each individual use of linked models and simulations should be accredited or examined well enough to provide the user of the analysis results with sufficient confidence in that use, the procedures for achieving that confidence is considered to be beyond the scope of this issue and its recommended workshop.

Issue 4: *How do we correctly use models of varying fidelity... of varying scale?*

Description: This issue directly addresses the challenges in linking that are not at a consistent level of fidelity. These may vary from engineering level models of individual systems through campaign-level warfare models. As a rule, representative existing models of different scale will also exhibit varying degrees of fidelity in many of the common features of each model "terrain," entity motion and system effects. Since there is a long history of linking such models indirectly (use of data from one model to parameterize another larger scale model), this issue implies direct linkage such as through DIS or an HLA federation. Questions to be resolved include:

1. Under what conditions are "fidelity conversion" algorithms possible to support direct linkage?

2. Under what conditions can differences in fidelity be dealt with after the fact through analysis?

3. Under what conditions can differences in fidelity be factored out of the analysis?

4. Under what conditions should direct linkage not be attempted?

[Reviewer Comment: "Variable Resolution" is a phrase frequently used to describe this concept. This issue is being considered in SIMTECH 2007]

Possible Approaches:

a. Assign the investigation of this area as a task for the MORS M&S Senior Advisory Group.

b. Request that the Defense Modeling and Simulation Office (DMSO) consider the area and issue guidelines for the use of M&S of varying fidelity and scale.

Issue 5: *Can current analysis management processes handle the new technologies and new modeling and simulation tools?*

Description: The ability to technically link models and simulations that previously could not interoperate offers a major step forward in capability and a corresponding management challenge. Past practices focused debate on single models or simulations and their ability to accurately portray military systems and operations. The debate over model credibility led to the demand for community standards for verification, validation and accreditation (VV&A). While not yet universal, these standards are currently under development and are being implemented with varying degrees of success. To date, VV&A for single function or single level of combat models has been largely tied to the credibility of the implementing analytic team and previous V&V investment in those models. New technologies and model linkages can now be implemented and data developed far more quickly than VV&A processes can be brought to bear to determine whether these applications or linkages are appropriate for the question at hand. Since many of these linked simulations incorporate powerful and convincing visual images, an otherwise sophisticated viewer might decide the results of these linkages are real even when there is no logical underpinning. In this environment, there are no fail-safe standards and no recognized DoD authority for decision makers to help determine if an application of a new technology or linkage is appropriate. The department needs to have clear processes or new organizations available to help judge whether a linked-model application can generate results reflective of those expected from real-world

operations. In particular, specific configuration control mechanisms need to be developed to ensure credible output without placing expensive bureaucratic burdens on the development process. Documentation, configuration control and reasonable VV&A standards are all part of the solution, but this is an area that may require new management processes and organizations within DoD to ensure cost-effective application of the new technological opportunities.

Possible Approach: Form a Joint OSD/Joint Staff/Service/M&S expert Process Action Team (PAT) to explore these issues in greater depth and offer solutions to senior leaders in the military community.

Issue 6: *How do we correctly treat uncertainty in M&S, in terms of measures, use of distributions, chaos, physics, behavior and balance of investment?*

Description: Warfare, perhaps more than any other human endeavor, is characterized by uncertainty. The major sources of uncertainty are well known: human behavior (especially under stress), the environment, the performance and reliability of complex systems, the "fog of war." We must deal not only with probabilistic outcomes from known distributions but also with outcomes from distributions of unknown form, of unknown outcomes from unknown distributions, of stochastic processes wherein the random phenomena develop over time in a probabilistic manner and even to chaotic phenomena. Many of our combat models and simulations treat uncertainty by collapsing the underlying probability distribution — of known or unknown form — to a single point value. Heading in the direction of the opposite extreme, Monte Carlo simulations use sampling techniques to directly combine known distributions that could be difficult or impossible to combine in closed analytic form. The very common assumption of statistical independence among events is another way of treating real-world uncertainty in order to make our models more mathematically tractable. Unfortunately, virtually all of the current methods of treating uncertainty have serious validity problems. "Statistical independence among events" almost never exists in problems of interest in the real world and can have an overwhelming impact on results. "Expected values" may not be likely or even feasible outcomes of their respective real-world distributions (giving rise to the reasonable question of why we use the term "expected value" at all). Monte Carlo techniques require knowledge or assumptions about the distributions of the variables. Bayesian models require full knowledge (or again assumptions) of the event space, etc.

When we are trying only to model things "in the small," isolated processes or events, or independent physical phenomena, the problem generally is manageable within the current body of theory and modeling technology. When we instead attempt to simulate at the entity-level, multiplatform engagements, campaigns and above, we are at best stretching the limits of the current body of theory. The overarching problem is that we are trying to combine and concatenate probability distributions over time — some of which may be of unknown form or may not be describable in closed form. The shape of a probability distribution at one point in time and space on the battlefield is determined by a myriad of predecessor events, each of which is governed by some other distribution. Each, in turn, depends on the outcome of earlier distributions. And the order of events in time also is a dependent variable. The mathematics of our current models and simulations appears inadequate to address such a problem. Alternative formulations (e.g., the various mathematics formulations of complexity theory or chaos theory) may be useful, or new theoretic research may be needed. At the moment, work in the theoretic area is seriously out-of-balance with the more tangible aspects of the new generation of simulations: systems engineering and software development, database development and infrastructure development. If the theoretic foundations of the new generation of simulations are weak or suspect; however, the potential return on our investment in those areas could be greatly diminished.

We first need to thoroughly define and scope the problem. Measures of Effectiveness (MOE) need to be defined to enable determining how

well simulations "treat uncertainty." As one possibility, MOEs may be identified that could statistically compare the outcome distributions of simulations against known or projected outcome distributions of the real world (at least at the engagement level). The theoretic underpinnings of at least the new simulations need to be made explicit and tested. Alternative formulations need to be reviewed and also tested both for generic applicability and specific use.

Possible Approach: The steps suggested above may be best taken through a series of focused MORS Workshops. The series would first accomplish the "define and scope" step, then (if found appropriate) use the results to critically stress the theory underlying representative current and new major simulations as well as alternative formulations. It is anticipated that the workshops would have a heavily theoretic/mathematic bent and would draw heavily from the academic community as well as the traditional interested organizations.

Issue 7: *How do we change culture (minimize resistance) to take advantage of new M&S technology? How do analysts get 'trust' in (lose 'fear' of) linked M&S?*

Description: The goal of analysts will remain to provide timely, complete and useful analysis to aid decision making. The challenge is to manage change in order to take advantage of new M&S technology and reduce the tendency to ignore, postpone or fear M&S technology and ADS.

Possible Approaches:

a. Use MORS Mini-Symposia and the MORS publications, *PHALANX* and the *Military Operations Research* journal to:

   (1) Communicate and explain new M&S technology to analysts and decision makers in language they understand.

   (2) Provide examples of both "good and bad" uses of M&S.

   (3) Share lessons learned in employing M&S.

b. Develop (through DMSO) new guidelines and/or emphasize existing guidelines which:

   (1) Promote analyst and decision maker involvement in conceptual development of linked M&S. Calibrate expectations of analysts and decision makers early and often.

   (2) Stress the use of disciplined configuration management to include providing early and complete documentation.

   (3) Emphasize the need to "really" understand the problem early in the form of a study plan that explicitly addresses M&S/ADS linkages.

Issue 8: *How do we better use test and evaluation (T&E) to support M&S validation for other functional areas, at all levels of M&S (particularly for linked M&S)?*

Description: Test data have long been used as the basis for M&S algorithm development, update of M&S parameters and to support the validation of M&S. Within the bounds of cost and resources available, test data are always desired ingredients for validation of M&S.

T&E, both developmental and operational, is more than a process to gather data for weapons system evaluation. That process includes a disciplined approach to:

a. Event planning to ensure needed data will be generated.

b. Instrumentation to ensure generated data will be captured.

c. Evaluation to properly convert test data to information.

The Simulation, Test and Evaluation Process (STEP) is a methodology that integrates simulation and test for the purpose of evaluating

the performance, military worth and effectiveness of systems under development. It represents a fundamental reengineering of current acquisition processes with very early involvement of the test community, up-front investment in essential M&S tools, a model-test-model paradigm with tests planned to obtain data essential to the M&S as well as the system evaluation and frequent assessments of the performance, military worth and effectiveness of the system. STEP has the potential, with appropriate identification of other M&S data needs, to provide essential data for a spectrum of M&S in all functional areas.

Several initiatives are underway to develop a synergism between the test and training communities to maximize the value both can obtain from increasingly limited resources of funding, facilities and infrastructure and manpower. Large-scale exercises and training events are unique opportunities to gather meaningful data to support development and validation of mission- and campaign-level M&S which are currently not well linked to higher resolution engagement and engineering models. With cooperation and proper planning, to include the identification and integration of M&S data needs from all areas, the T&E community can gather required data from these events.

Possible Approaches:

a. Use a MORS Workshop to lay out structure and process for identifying M&S development and validation data needs from all functional areas.

b. Recommend DTSE&E consider guidelines for the expanded use of T&E processes and instrumentation to capture data useful for validation of mission and campaign M&S.

Issue 9: *How do analysts get visibility into M&S, including visibility into legacy M&S, linked M&S and proprietary M&S?*

Description: The world of M&S is evolving from one where modelers and analysts work closely together to develop or modify a model to solve a particular problem, to one where there will be a limited number of modeling efforts developed somewhat independent of the application and somewhat independent of the analyst. More integrated modeling efforts are necessary to reduce duplication and to coordinate V&V efforts. However, in the move to increase efficiency, the model development effort and the analysis efforts have become separated. As a result, there is a real danger that the user of a model may not fully understand the model limitations. An unknown or misunderstood assumption in a model can result in misleading or incorrect study conclusions. The issue is one of ensuring that model users, who were not involved in the model development, can gain visibility into a model developed independent of the application in order to assure that the model can be used correctly.

In some of the early MORS workshops, it was recognized that there were numerous modeling efforts taking place within the DoD and that many of these efforts were duplicates of other efforts. This was not due to a deliberate attempt to ignore parallel efforts, but simply due to lack of communication and the lack of necessity to coordinate, because there was enough money to fund independent efforts.

The increased attention to M&S and the decrease in the defense budget caused the initiation of major "generic" modeling efforts: JMASS, JWARS and JSIMS — designed as architectures that will serve common applications; thus, it is hoped, reducing the number and cost of duplicate model development efforts.

If the analyst is not a part of the model development, then how can he/she gain the insight to the model strengths and weaknesses? One answer is model validation, ensuring that the model adequately represents those parts of the real world important to the particular application. However, without a full knowledge of the model, the tendency is to overstress the validation process. This drives up the cost of application, because it is not tailored by a thorough knowledge of both the model and the

application. Where we may have saved money in model development, we may be spending more money in the application.

This problem is compounded by distributed model applications, where different assumptions may be incompatible for a particular application and areas such as legacy and proprietary models.

Possible Approach: Hold a MORS Workshop to define mechanisms for gaining the required visibility into M&S to assure adequate understanding and correct use of results.

Issue 10: *How will cost of M&S maintenance for use by other users be budgeted by M&S sponsors?*

Description: The DoD is making significant investments in models, simulations, architectures and standards in an attempt to encourage reuse by the community of a family of standard models. JMASS, JSIMS, JWARS and HLA are a few standard model notable examples. In addition, some legacy models, already in use in the field, will be required to become HLA compliant. In general the developers of JMASS, JSIMS and JWARS may use their models, but they will represent a small minority of users if the reuse goals are achieved. So the basic issue is what plans have been made by the builders of these models to support their use by the majority of the M&S community? The maintenance and configuration management costs are likely to rise swiftly as more contractors attempt to use the standard models to develop business opportunities.

Possible Approach: Form a Joint Process Action Team (PAT) to address the issue of the funding of M&S maintenance.

COMMON TECHNICAL FRAMEWORK/ HIGH LEVEL ARCHITECTURE (HLA) TUTORIAL

Dr. Judith Dahmann

The High Level Architecture provides the specification of a common technical architecture for use across all classes of simulations in the DoD. It provides the structural basis for simulation interoperability. The baseline definition of the HLA includes the HLA Rules, the HLA Interface Specification and the HLA Object Model Template. The HLA Rules are a set of ten basic rules that define the responsibilities and relationships among the components of an HLA federation. The HLA Interface Specification provides a specification of the functional interfaces between HLA federates and the HLA Runtime Infrastructure. The HLA Object Model Template provides a common presentation format for HLA Simulation and Federation Object Models.

The MORS HLA Tutorial provides a technical description of the three components of the Common Technical Framework (CTF) for Modeling and Simulation. An introduction to the CTF was given by Dr. Judith Dahmann (Chief Scientist, DMSO). An overview of the Conceptual Models of the Mission Space (CMMS) and Data Engineering efforts was given by Mr. Jack Sheehan of DMSO. Following this, an overview of the HLA Rules and Interface Specification was given by Dr. Dahmann. The HLA Time Management services are discussed by Prof. Richard Fujimoto (Georgia Institute of Technology). An overview of the HLA Object Model Template was given by Mr. Bob Lutz (The Johns Hopkins University Applied Physics Lab) and an HLA use-case was given by Mr. Kent Pickett (TRAC, Ft. Leavenworth).

ABSTRACTS

SEGMENT A — Analytic M&S Linkages

Session A1 — Linkage of Multilevel M&S

Linking Engineering-Level Models to the Campaign Analysis
Charles "Chuck" Burdick, Lockheed-Martin

Computer based military analysis has typically occurred on a "slice of the battlefield." With enough resources, it can be a very big slice, but generally, to conserve computing power, only selected portions or units in the battlespace are represented. Where large scale effects are desired, aggregation of units, terrain, time and/or interactions are typically employed. The quest for higher fidelity models operating on a much larger scale is currently consuming considerable M&S funds. The problem is that even with large increases in computer processing power, high fidelity still takes enormous computer resources to produce a realistic looking battlefield populated with a large number (> 5,000) of individual platforms.

As an alternative to simulating all elements of a scenario at a high level of fidelity, this presentation addressed the opportunities and challenges of generating detailed slices "on demand." Within these slices, one can obtain detailed interactions in a much larger context than can be supported with current computer resources. This briefing provided some background on recent disaggregation efforts for both units and weapons within a DIS environment. It also addressed the technical challenges and analytical issues associated with disaggregation and the real time linking of engineering level models with campaign level wargames.

J-MASS, JWARS, JSIMS Linkage
Major Bill Reed, USAF/XOC

This briefing considered the role of J-MASS within the context of the Air Force M&S Master Plan. It represents the collective effort of staff and program managers responsible for developing a corporate AF strategy for implementing the three thrusts of the AF M&S Roadmap and Master Plan: quality, people and infrastructure.

This briefing addressed the third of these thrusts: developing the infrastructure needed to support the common synthetic battlespace. The AF M&S Master Plan and Roadmap highlight three joint infrastructure programs and believes that together their implementation will create the needed supporting infrastructure and represents a major step toward the common synthetic battlespace vision.

The specific purpose of the briefing was two fold:

(1) To clarify the role of J-MASS in the AF M&S Vision and establish its relationship with other elements of that vision.

(2) To put forward a strategy for implementing the AF M&S vision considering the objectives of its elements. This strategy takes the form of a set of recommendations that consider fiscal constraints and practical requirements to extend the vision established in the AF 4-Star M&S summit.

IABG Approach to Hierarchy of Models and Data
Heinz Nobis, IABG

Since the early 70s, IABG has been developing and using simulation models and wargames for research purposes as well as for training and exercises. Requirements for different resolution were solved by a hierarchical approach.

Presently model families are available which cover the area from battalion level to theater level. The model at each level may be used as research or training tools on its own, or as a means to generate a database to be evaluated and

aggregated for the next higher model in the hierarchy.

These aggregation processes are automated, using traditional statistic methods as well as new ones like the evolution theory. In one of the previous efforts, for instance, some 500 battalion simulation runs generated the database for the brigade to corps levels and some 50 brigade simulation runs were used to build the database for the theater level simulation.

In addition to this aggregation process, a message based concept was developed to connect the different submodels within a model family. This allows the running of "plug compatible" submodels at different resolution within the model family. One example at corps level is the simulation of logistics. Using the same interface, this subject can be represented by two models with different resolutions, which may execute simultaneously — each supporting one of the opposing forces. The realization of these approaches is facilitated by a simulation software package, developed at IABG, which is used to program and implement all models.

Session A2 — Linkage of Cross-function/Cross-community M&S

M&S as an Enabler of Integrated Product and Process Development (IPPD)
Anne Patenaude, SAIC

There is pervasive evidence of Modeling and Simulation (M&S) being used effectively and efficiently in the DoD system acquisition process by every Service, though not in the same way and not yet seamlessly throughout a program. Both government and industry are identifying and developing tools that bring added benefit to their program's development.

Although M&S tools have long been used to support the systems acquisition process, advances in technology have made these tools more powerful and less expensive. This, together with declining resources and changing priorities, provided the right environment to use M&S as a key in finding better ways to develop and field new systems. Evaluating processes and emerging requirements have been supported by powerful new M&S tools which have been integrated into weapon system acquisition.
This presentation provides some of the findings of a study commissioned to identify the effectiveness or value of M&S tools and processes in the acquisition process.

Linking Requirements to Test Using the Simulation, Test and Evaluation Process
Major William Norton, OUSD (A&T)/DTSE&E

The acquisition of weapon systems within the DoD has been undergoing dramatic changes in recent years. This has been in response to budget pressures which dictate that systems be developed and fielded faster, at lower cost and still have improved performance. The principal features of acquisition reform have been an emphasis on performance-based requirements, simulation-based acquisition and integrated teaming of all participants. The testers which support the acquisition process must also change to bring themselves into alignment with the new realities. This includes better integration with all other program activities and testing formulated to answer technical and operational critical issues in response to requirements. The testers must address the frequently heard criticisms that their testing costs too much, takes too long and yields results of limited value to the program. This must also be accomplished against a backdrop of shrinking resources and organizational realignments. The vision for the changes include greater incorporation of modeling and simulation (M&S), earlier involvement with the program and test planning focused on demonstrating the military worth of a system.

The Simulation, Test and Evaluation Process (STEP) is intended to provide the linkage between the M&S supporting the system definition and testing such that they become interdependent. In doing this, STEP will help ensure that tests seek to assess the military worth of the weapon, provide data to validate M&S, are designed to answer critical program issues, are integrated with other program activities and work to reduce overall program risk. The STEP includes several vital features. It possesses an

iterative routine by which test data is used to improve the fidelity of the M&S which, in turn, is used to guide the next series of tests. This supports the efficient and effective model-test-model paradigm. Test planning and execution will reflect the clear linkage between tests and the Measures of Performance (MOP) derived from the measures of effectiveness, which are in turn derived from clear operational imperatives revealed through M&S.

Implementing STEP across the DoD involves the necessary M&S infrastructure and re-engineering within the test and evaluation community to align themselves to the new paradigms. Each of these requirements have many challenges to overcome for successful achievement.

Joint Campaign Analysis Methodology and Tools
Dean Free, OCNO/N81

The Navy Assessment Division (N81) directs the Navy assessment process which culminates in the Investment Balance Review. The Navy conducts trade-off analyses to determine the most cost-effective options for modernization, force structure, readiness and sustainment.

N81 uses an analysis methodology which identifies the impact of naval force options on the air/land battle using joint campaign analysis. This methodology and attending M&S tools were described in this presentation with emphasis on use of modern technology to develop tools to link engagement and mission level results to the joint campaign, to link cost models to warfighting effectiveness, and to provide cross-mission, cross-platform tradeoffs across naval joint mission areas.

Session A3 — Linkage of Cross-function/Cross-community M&S

Anti-Armor Advanced Technology Demonstrator (A2ATD) Lessons Learned
Tom Ruth, USA AMSAA

The Anti-Armor Advanced Technology Demonstrator is a joint Army/DoD program that was initiated with the goal of maturing DIS as a credible evaluation tool to support acquisition decisions. The purpose of the A2 ATD is to develop and demonstrate a Verified, Validated and Accredited (VV&A) DIS capability for heavy and light force anti-armor evaluations.

This presentation provided an overview of the A2 ATD, guidelines for executing a credible DIS experiment on either a Local (LAN) or a Wide (WAN) Area Network, issues that need to be addressed prior to conducting a credible experiment, and lessons learned from the six A2 ATD experiments.

Integrating Testing and Training
George Rumford, OUSD (A&T)/DTSE&E

Testing and Training are inherently different. Testing requires a controlled environment to effectively measure identified performance parameters, whether it be compared to specifications (Developmental Testing) or in an operational context (Operational Testing). On the other hand, training is conducted to obtain force proficiency in warfighting and, therefore, desires a more free play environment. Nevertheless, it has been proposed that benefits, in terms of reduced cost, time and risk for acquisition as well as improved training for forces, can be obtained if the two domains were more integrated. Four major ways to integrate test and training have been suggested:

- Conduct testing in the realistic environment of a training exercise.
- Perform training during a test event.
- Share unique resources to avoid duplication between communities.
- Develop common instrumentation for cost savings.

The first two methods depend on interoperability while the latter revolve around reusability. The proposed universal solution for the two communities is the synthetic battlespace: a common range-like environment, accessible

from multiple labs, ranges and facilities that integrates live and synthetic resources for the purpose of system development, operational evaluation and training.

In determining the components of this synthetic battlespace, we recognized that every training range, test range, hardware-in-the-loop (HWIL) facility, installed systems test facility (ISTF), and simulation system possess several common requisite components:

- Environment (to stimulate the system under test, training participant, or digital model).
- Data Acquisition (to collect data on how well the system, operator, or model performed).
- Operational Control and Support (to transmit, process, display, and control the exercise).
- Architecture (the methodology used to piece the above components together).

To achieve interoperability and reusability for the synthetic battlespace, we have embraced the High Level Architecture (HLA) as the common technical framework to exchange data, as well as initiated the Test and Training Enabling Architecture (TENA) project to determine specific architectural requirements for testing and training. Furthermore, we have started the Virtual Test and Training Range (VTTR) project to acquire common control tools for configuring and operating the synthetic battlespace. Ultimately, we concede, to cost-effectively reconfigure and to timely schedule the battlespace, a common management approach, or business process, must be adopted and have therefore slated the Joint Regional Range Complex (JRRC) project to address those issues.

The prime issue for test and training integration is the degree of commonality attainable. From the functional component analysis above, it seems that common control tools for exercises are more attainable than a common environment, or Conceptual Model of the Mission Space (CMMS), since the environment generated is directly related and tightly coupled to the system under test, training participant, or digital model. Therefore, it is opined we should proceed aggressively in the pursuit of common tools and cautiously in the definition of a universal CMMS.

SEGMENT B — New Technologies Supporting Analysis

Session B1 — Linking Through a Common Understanding of the Battlespace

Linking Through a Common Understanding of the Battlespace: JWARS and the JWARS/JSIMS Conceptual Model of the Mission Space (J2CMMS)
LTC Terry W. Prosser, Deputy Director, JWARS

The Department of Defense uses many analytical modeling tools for the Defense Planning, Programming and Budgeting System (PPBS) analysis, Unified and Specified Commander in Chief (CINC) course of action development and defense establishment force structure and readiness assessments. The Joint Warfare System (JWARS) project is a Deputy Secretary of Defense-directed initiative to develop an analytical model which will meet OSD, Joint Staff, CINC and service requirements. The Joint Simulation System (JSIMS) program is a program to produce a training model to conduct joint force training. Although the models serve different purposes (analysis and training), both JWARS and JSIMS must model the same military mission space. The J2CMMS is a joint venture between JWARS and JSIMS to collaborate in developing the research and analysis that begins the simulation development process.

This briefing discussed the role of a CMMS in simulation development. It also discussed the CMMS as a tool for sharing a common understanding of the military mission space. It

provides an example of how a CMMS supports simulation development and lessons learned during JWARS prototype development.

The Use of Advanced Distributed Simulation for Analysis

Guy Carrier, Joseph Manzo and Jeffrey Opper, The MITRE Corporation

Advanced Distributed Simulation, entity level simulation based on distributed interactive simulation and the evolving high level architecture technologies, has typically served as the simulation and stimulation tool supporting training applications. The Joint Countermine Operational Simulation (JCOS) project has as its objectives the use of ADS to support joint training as well as to conduct course of action analysis and the analysis of the "military utility" of a family of Army, Navy and Marine Corps countermine systems.

To use ADS to support analysis it is necessary to augment the usual visual output used in ADS training applications with an easily implementable experimental design and after action review system. The experimental design system, the JCOS Exercise Management and Control System (EMCS), allows the user to more easily design the experiment and reproduce the design for repeatability in subsequent experimental trails. The JCOS After Action Review System (AARS) empowers the user to extract detailed performance metrics from the simulation results.

The JCOS EMCS provides a user friendly environment that gives the analyst the capability to quickly set up the experiment, defining the hardware and software configuration and the data gathering strategy within the ADS environment. The EMCS also stores the results of the simulation as well as the configuration information for comparison with subsequent experimental trials.

The JCOS AARS supports evaluation, analysis, and performance assessment. The AARS consists of several components that facilitate exercise preparation supporting training or analysis objectives, provide real-time monitoring and scanning with 2-D tactical map displays and 3-D "stealth" visualizations of the battlespace, compile exercise data, and permit statistical analysis using both established and customized measures of performance and measures of effectiveness.

The data collection and analysis components of the AARS will consist of three major subsystems: a COTS relational database used as the primary AAAR data repository; data logger/loader agents which will capture simulation network traffic, filter and parse the individual messages, stage relevant data at each site, and forward the data to the AARS repository; and a COTS World Wide Web (WWW) browser. The browser will provide the user with the capability to access the repository using stored and ad-hoc queries and download a variety of data directly to desktop applications such as spreadsheets and presentation graphics products.

Session B2 — Linking Statically Through Data Sharing

Linking Simulations Through Common Data

Jack Sheehan, Applied Research Laboratory/ University of Texas

Data is a critical component of the Defense Modeling and Simulation Office (DMSO) composable solutions strategy for improving simulation credibility and reducing cost. This paper discussed four key issues which arise when solutions are composed by linking the output data from one or more simulations to the input data of subsequent simulations: common semantics and syntax for data recognition, systems architecture for data realization, development processes for data repeatability and standard products for data reuse. Specific issues were illustrated using concrete examples from a ballistic missile defense context.

Insights Moving Toward a Data Management System

Captain Byron Tatsumi, AFSAA/SAGD

Prior analytic efforts have often been poorly linked and coordinated across the multiple modeling tools and branches within the agency.

With lower task loads, long lead times and adequate manpower, it was possible to execute analyses based upon the "customer's" preferred scenario region and time frame. Today, with large task loads, very short lead times and inadequate manpower, standardized databases are needed to help improve the efficiency and effectiveness of studies and analyses. The purpose of AFSAA's database management system is threefold: improve study credibility and consistency by providing a common source of data; improve the efficiency of the study process by automating data entry; and improve the effectiveness of the study process by making tools to organize, track and archive studies. AFSAA has learned some lessons about the problems in developing a database management system and had experienced some successes in moving toward one.

Session B3 — Linking Dynamically at Runtime

The Value of Air Defense Protection to the Force-on-Force Battle
Richard L. Calkins, U.S. Army TRADOC Analysis Center

The VIC-EADSIM confederation originated as an effort to develop an Air Defense Analysis tool to address Theater Missile Defense (TMD) Integration application. Specifically, to evaluate the protection that air defense provides to the force-on-force battle.

This analysis tool links TRAC's primary force-on-force model, Vector-in-Commander (VIC), to the Space and Strategic Defense Command's (SSDC) new air defense model, the Extended Air Defense Simulation (EADSIM). The VIC-EADSIM confederation will operate within an ALSP-DIS architecture, exchanging key functional information across a network and allowing the simulations to operate in a synchronous manor while executing at a simulation speed. The product of this effort will provide the capability to conduct 'value-added' analysis on the contribution of a new or improved air defense system to the maneuver battle over the entire vertical slice of the air defense environment, and answer the 'so-what' questions that have typically been addressed subjectively or remain unanswered.

In operation, VIC will be conducting a Corps slice of an EADSIM theater campaign. The Corps battle will consist of all elements of a maneuver operation to include: direct and indirect fire; the collection, processing and dissemination of intelligence; tactical command, control and communication; NBC; and, CSS operations. VIC's linkage to EADSIM will permit the leakers resulting from a TBM attack in EADSIM to penetrate and affect the maneuver operations. Early warning information passed to VIC and EADSIM radar's, will permit the evaluation of passive defense measures executed by the affected portion of the maneuver force. Intelligence information about threat launchers exchanged between the simulations can spawn attack- operations from within VIC or EADSIM.

Joint Precision Strike Counter MRL ACTD "Using Simulation to Solve Real Warfighter Problems"
Russ Richardson, SAIC/ JPSD

In the first half of FY 94 a significant tactical threat emerged within North Korea which quickly become the number one priority of the USFK CINC. The threat which was being deployed in hardened shelters within caves was the 240 Multiple Rocket Launcher (MRL) and 170 Gun. OSD and SARD initiated a program as an ACTD within the Joint Precision Strike Program Office to develop a solution to the MRL threat and field it to USFK by the end of FY 96. To explore alternative sensor to shooter concepts through simulation and field exercises JPSD developed the Integration and Evaluation Center at Ft Belvoir. Concepts were first explored in constructive simulation and as systems, TTPs and functionality were culled more detailed simulations where used with increasing numbers of real systems and soldiers in-the-loop. The resulting exercise which utilized aggregate and entity level simulation stimulating go-to-war command and control systems with live sensors and shooters in the loop produced qualitative data justifying the recommended architecture. The process of

simulate, exercise, simulate, resulted in a continual refinement of the solution that allowed fielding of a counter MRL capability at 2nd ID in October 96. The presentation discusses how simulation played the key role in developing the solution, and getting the buy in/confidence from Theater to accept the solution. Details of the approach, simulation structure, and results gained from the use of simulations are discussed.

M&S In C2 Acquisition Analysis an Test
Col. Hoot Gibson, Chief, Modeling, Simulation and Advanced Systems Division, ESC/XRP

The Modeling, Analysis and Simulation Center (MASC) and the Command and Control Unified Battlespace Environment (CUBE) at Electronic Systems Center (ESC), Hanscom AFB, MA, are teaming to develop innovative methodologies for technology infusion into and interoperability testing of command and control (C2) equipment. Of particular interest is the role of modeling and simulation: Analytic tools such as EADSIM and training tools such as AWSIM are being used to stimulate the C2 equipment under investigation, much as threat radar simulators on test ranges stimulate the airborne electronic countermeasures equipment. In the case of the Common Operating Picture (COP) study, the MASC varied the number of aircraft and message traffic densities in a MOOTW scenario to help highlight strengths and weaknesses of five OSD and service COP equipments. This presentation concluded with a brief overview of efforts the CUBE has undertaken to reduce interoperability problems with the Combined Air Operations Center in Vicenza, Italy

AGENDA

Monday, February 24, 1997

1100-1800 Early Registration

1330-1700 Common Technical Framework/HLA Tutorial
Dr. Judith Dahmann (DMSO), Mr. Jack Sheehan (U Texas/DMSO),
Prof. Richard Fujimoto (GIT), Mr. Robert Lutz (JHU/APL),
Mr. Kent Pickett (TRAC, Ft. Leavenworth)

Tuesday, February 25, 1997

0700-0815 Registration

0815-0820 Call to Order, Administrative announcements
Jim Sikora (Mini-symposium Co-chair)

0820-0850 Welcome
Dr. Marion Williams (Mini-symposium Co-chair),
Fred Hartman (MORS President)

850-915 Purpose and Overview of Mini-Symposium
Jim Sikora (Mini-symposium Co-chair)

0915-0930 Break

SEGMENT A - Analytic M&S Linkages
Co-chairs: Dr. Hank Dubin (USAOPTEC), Dick Helmuth (SAIC)

0930-1130 Session A1 - Linkage of Multilevel M&S
Co-chairs: Paul Hommert (SNL), Walt Stanley (BDM)

Linking Engineering Level Models to the Campaign Analysis
Chuck Burdick (Lockheed-Martin)

JMASS, JSIMS, JWARS Linkage
Maj Bill Reed (AF/XOC)

Approach to Hierarchy of Models and Data
Heinz Nobis (IABG)

1130-1300 Lunch

1300-1500 Session A2 - Linkage of Cross-function/Cross-community M&S
Co-chairs: Adm Ted Parker (USN, Ret), LtCol Frank Swehosky (AFOTEC)

M&S as an Enabler of Integrated Product and Process Development (IPPD)
Anne Patenaude (SAIC)

1300-1500 Session A2 - Linkage of Cross-function/Cross-community M&S (cont.)

Linking Requirements to Test Using the Simulation Test & Evaluation Process
Maj Bill Norton (OUSD (A&T)/DTSE&E)

Joint Campaign Analysis Methodology and Tools
Dean Free (OCNO/N81)

1500-1515 Break

1515-1715 Session A3 - Linkage of Cross-function/Cross-community M&S
Co-chairs: Dr. John Friel (RAND), Col Mark Smith (JADS JTF)

Anti-Armor Advanced Technology Demonstration (A2ATD) Lessons Learned
Tom Ruth (USA AMSAA)

Virtual Test and Training Range
George Rumford (OUSD (A&T)/DTSE&E)

Cross-Community Issues
Dr. Hank Dubin (USA OPTEC)

1715-1900 Mixer

Wednesday, February 26, 1997

SEGMENT B - New Technologies Supporting Analysis
Co-chairs: Judith Dahmann (DMSO), Col Tom Allen (USAFSAA)

0800-1000 Session B1 - Linking Through a Common Understanding of the Battlespace
Chair: Bob Might (George Mason University)

JWARS and the JWARS/JSIMS Conceptual Model of the Mission Space (JCMMS)
LTC Terry Prosser (JWARS)

Joint Countermine Operational Simulation (JCOS): Use of Advanced Distributed Simulation for Analysis
Guy Carrier (MITRE), Joseph Manzo (MITRE)

1000-1015 Break

1015-1200 Session B2 - Linking Statically Through Data Sharing
Chair: Bob Lutz (JHU/APL)

Linking Simulations Through Common Data
Jack Sheehan (Univ of Texas/DMSO)

Insights Moving Toward a Data Management System
Capt Byron Tatsumi (USAFSAA/SAGD)

1200-1330	Lunch
1330-1530	Session B3 - Linking Dynamically at Runtime Chair: Kent Pickett (TRAC)
	VIC-EADSIM: Value of Air Defense Protection to the Force-on-Force Battle Richard Calkins (TRAC)
	Joint Precision Strike Demonstration (JPSD) Counter Multiple Rocket Launchers Advanced Concept Technology Demonstration (ACTD) Russ Richardson (SAIC)
	Modeling, Analysis and Simulation Center (MASC)/Command and Control Unified Battlespace Environment (CUBE): Modeling and Simulation in C2 Acquisition Analysis & Test Col Richard 'Hoot' Gibson (ESC/XRP)
1545-1600	Break
1600-1700	Panel/Summary Moderator: Marion Williams (Mini-symposium Co-chair) Panel Members: Segment Co-chairs, MORS Sponsors' Representatives

TERMS OF REFERENCE

MILITARY OPERATIONS RESEARCH SOCIETY (MORS)
COMPLEXITY IN MODELS AND SIMULATIONS MINI-SYMPOSIUM
FEBRUARY 25-26, 1997

Background

The use of modeling and simulation (M&S) of military systems has dramatically increased because of decreasing DoD budgets and rapidly advancing computer and software technology. There has been an explosion of new M&S projects to take advantage of this new, more efficient technology and to create cheaper to use, more capable tools to use for military applications. The advancing M&S technology areas include methodologies and techniques for linking different M&S together as well as for use in conjunction with other warfare analysis tools. The ability to technically link various models has increased significantly, but now we must also determine how to 'logically' link to achieve analytically sound results. There are issues concerning the ability to link or integrate the M&S for any particular application. These issues involve the linking of models of different levels and types. As an example of different type linkage, the linkage of a cost model and a performance model has been accomplished by analytically combining each models results. Are there more effective and faster means of accomplishing this linkage? A similar situation exists for linking the executions of different level of models, for example, a theater level model and a mission level model.

Another area which will affect the linkage and integration of M&S is the use of common M&S elements and standards. This commonality is particularly important because of increasing M&S requirements and decreasing budgets for satisfying those requirements.

Objectives

The objectives of the proposed Mini-Symposium are to:

(1) Review new current and future M&S linkage activities and projects with a focus on the impact on analysis applications and analysis capabilities. The focus will also include the activity/project objectives/requirements as well as any linkage lessons learned.

(2) Increase the military application community's understanding of M&S linkage issues, problems and potential solutions.

(3) Provide interface/interactions among the members of the military applications community in the area of M&S linkage.

Agenda

The agenda for the two day unclassified Mini-Symposium will contain the following two major segments:

Segment A. Analytic M&S Linkages

Session 1. Linkage of Multilevel M&S (e.g., theater and mission level models)

Session 2. Linkage of Cross-function M&S (e.g., cost and performance models)

Session 3. Linkage of Cross-community M&S (e.g., acquisition and analysis)
— includes linkage across the systems acquisition cycle.

Segment B. Linkage of M&S through Technical Enablers (e.g., Common Technical Framework)

Session 1. Common View of the Battlefield (e.g., Common Model of the Mission Space)

Session 2. Common M&S Architectures (e.g., HLA)

Session 3. Common Data

The Mini-Symposium will begin with a short introduction and overview the M&S linkage area, a summary of the linkage issues and concerns, the Mini-Symposium objectives, and an overview of the Mini-Symposium agenda. A keynote speaker will set the stage with a broader context for M&S linkage. The remainder of the first day will be taken up with Segment A — Analytic Linkage. The second day will contain Segment B — Linkage Through Technical Enablers. The Mini-Symposium will close with a short summary of the issues and concerns based on the presentations.

In addressing the question of analytic linkage, special attention will be paid to the issues associated with developing and applying self consistent measures of merit (e.g., measures of effectiveness, measures of performance) and scenarios. In the former area, the Mini-Symposium will take advantage of prior MORS workshops on C3I Measures of Effectiveness. In addition, the Mini-Symposium will take advantage of the results of the recent MORS workshop on Advanced Distributed Simulation.

Products

The product of the Mini-Symposium will be a report of the state-of-the-art in M&S linkage and the current issues and concerns. The report will be produced by the following steps.

(1) The segment Co-chairs will produce a graphic and text summary for their segment. It will contain the segment purpose/scope, a synopsis of each presentation explicitly listing any lessons-learned, and a list of problems and

issues discussed with any identified potential solutions. This summary is due to the Mini-Symposium Co-chairs within 3 weeks after the Mini-Symposium ends.

(2) The Mini-Symposium chairs will review and integrate the segment Co-chair summaries. They will develop and add a Mini-Symposium summary and an integrated set of issue and problems with identified potential solutions. This will be completed within 5 weeks after the Mini-Symposium ends. This will be provided to MORS publications in both paper and electronic (PC Word) format. From this, a letter will be developed to Dr. Anita Jones, DDR&E, identifying the issues and concerns for her consideration.

In addition, the report will be put in a form suitable for publishing in the *PHALANX* and a briefing will be prepared for the MORS Sponsors and the 65th MORSS.

Membership

The Mini-Symposium Co-chairs will be Dr. Marion Williams, FS, of the Air Force Operational Test and Evaluation Center and Mr. James Sikora, FS, of BDM International. The chairs will control the attendance so that it falls in the range of 150-250. Active use will be made of members of the appropriate MORS working groups

Co-chairs for Segment A are Dr. Patricia Sanders, OUSD (A&T)/DTSE-E, and Dr. Henry Dubin, USAOPTEC, and for Segment B are Dr. Judith Dahmann, DMSO, and Col Thomas Allen, AFSAA/CC, who will moderate segment discussions and will take responsibility for participating in the final Mini-Symposium summary.

Attendance will be by invitation to those who (1) have current experience with linkage methods or related technologies, or (2) have near-term project/program M&S linkage concerns and issues.

Schedule and Fees

The Mini-Symposium will be held in Albuquerque, NM at Sandia National Laboratory's Technology Transfer Center on February 25-26, 1997. The fee is anticipated to be $175 for federal government employees and $350 for all others. This fee structure will be part of the management plan developed by the MORS Office, the MORS Mini-Symposium advisor (Priscilla Glasow) and the Mini-Symposium Co-chairs.

November 1, 1996

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Complexity in Modeling and Simulation - Linkage Acronyms List

A2 ATD	Anti-Armor Advanced Technology Demonstrator
AARS	After Action Review System
ADS	Advanced Distributed Simulation
C2	Command and Control
CINC	Commander in Chief
CMMS	Conceptual Models of the Mission Space
COP	Common Operating Picture
COTS	Commercial Off The Shelf
CSS	Combat Support System
CTF	Common Technical Framework
CUBE	Control Unit Battlespace Environment
DIS	Distributed Interactive Simulation
DMSO	Defense Modeling and Simulation Office
DTSE&E	Director Test Systems Engineering & Evaluation
EADSIM	Extended Air Defense Simulation
EMCS	Exercise Management and Control System
ESC	Electronic Systems Center
HLA	High Level Framework
HWIL	Hardware-in-the-Loop
IPPD	Integrated Product and Process Development
ISTF	Installed Systems Test Facility
J2CMMS	JWARS and the JWARS/JSIMS Conceptual Model of the Mission Space
JCOS	Joint Countermine Operational Simulation
JMASS	Joint Modeling and Simulation
JRRC	Joint Regional Range Complex
JSIMS	Joint Simulation System
JWARS	Joint Warfare System
LAN	Local Area Network
M&S	Modeling and Simulation
MASC	Modeling, Analysis, and Simulation Center
MOE	Measures of Effectiveness
MOOTW	Military Operations Other Than War
MOP	Measures of Performance
MRL	Multiple Rocket Launcher
N81	Navy Assessment Division
NBC	Nuclear, Biological, Chemical
OSD	Office of the Secretary of Defense
OUSD	Office Under Secretary Defense
PAT	Process Action Team
PPBS	Planning, Programming, and Budgeting System
SIMVAL	Simulation Validation
SSDS	Space and Strategic Defense Command's
STEP	Simulation, Test, and Evaluation Process

T&E	Test and Evaluation
TBM	Tactical Ballistic Missile
TENA	T & E Enabling Architecture
TMD	Theater Missile Defense
VIC	Vector in Command
VTTR	Virtual Test and Training Range
VV&A	Verification, Validation, and Accreditation
WAN	Wide Area Network